

B737NG Alerting Issues – Stall

1. Initiating Condition: High altitude airspeed decay with turbulence, autopilot engaged

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	Flashing box on digital airspeed display	AOA-compensated airspeed, not g-compensated				Increased airspeed
	PLI on PFD/EADI nears/touches airplane symbol	AOA				Reduction of AOA
Aural Alerts	Airspeed Low (if installed based on EGPWS model)	AOA-compensated airspeed, not g-compensated				Increased airspeed
	Stick shaker (sound of)	AOA				Reduction of AOA
Tactile Alerts	Stick shaker	AOA				Reduction of AOA
Visual Cues	Airspeed indication in amber or red/black range	Top of amber band is minimum maneuvering speed (AOA compensated but not g-compensated). Bottom of amber=top of red/black band is stick shaker onset and is g-compensated. (See B737 FCTM p. 1.4)				Reduction of AOA

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1. Initiating Condition: High altitude airspeed decay with turbulence, autopilot engaged – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Cues	Amber “LE Devices” on Annunciator Panel	Approaching stall angle of attack			As the aircraft approaches the stall angle, the slats automatically drive to the FULL EXTEND position prior to stick shaker activation.	The slats return to the EXTEND position when the pitch angle is sufficiently reduced below the stall critical attitude.
	PFD/ADI indications of uncommanded pitch		Uncommanded pitch/roll and sink rate cues are not normally presented in training, so pilots may be less likely to interpret them as signifying a stall (especially in the absence of stick shaker cues) and also more likely to be distracted by them from stall diagnosis and recovery actions.			
	Roll rate on PFD/EADI		Uncommanded pitch/roll and sink rate cues are not normally presented in training, so pilots may be less likely to interpret them as signifying a stall (especially in the absence of stick shaker cues) and also more likely to be distracted by them from stall diagnosis and recovery actions.		Uncommanded roll cues masked by autopilot roll inputs until the a/p disconnects (appears as wheel deflection, see below); however, rapid roll may accompany a/p disconnect at the stall.	

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1. Initiating Condition: High altitude airspeed decay with turbulence, autopilot engaged – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
	Sink rate on vertical speed display		Uncommanded pitch/roll and sink rate cues are not normally presented in training, so pilots may be less likely to interpret them as signifying a stall (especially in the absence of stick shaker cues) and also more likely to be distracted by them from stall diagnosis and recovery actions.			
	Wheel may move opposite the roll if autopilot is engaged					
	Trim wheel motion					
Aural Cues	None					
Tactile/Somatic Cues	Aerodynamic buffet	AOA (natural)	Can be confused with high speed buffet			Reduction of AOA

Expected Pilot Response(s)

- Disconnect autopilot and autothrottle
- Apply nose down pitch control until stall warning is eliminated
- Apply nose-down trim as needed
- Roll wings level
- Adjust thrust as needed
- Check speedbrakes retracted
- Return to the desired flightpath

Possible sources of confusion with regard to pilot response(s)

B737NG Alerting Issues – Stall

1. Initiating Condition: High altitude airspeed decay with turbulence, autopilot engaged – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
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- Autopilot may trim into low airspeed condition before disconnecting, resulting in nose-up pitch rate and greater need to re-trim during recovery.
- Autopilot may disconnect while holding wheel input, resulting in rapid roll at the time of disconnection.
- Uncommanded pitch/roll and sink rate cues also can result from other events besides stall, thus not necessarily signaling stall recovery to the pilot. Also these cues can draw the pilot's attention away from stall diagnosis or recovery actions.
- High altitude stall may require greater nose-down input than the stalls trained in the simulator.
- High altitude stall may lead to high speed buffet during recovery, with cues similar to low-speed buffet but different recovery actions required.
- Erroneous pilot inputs (i.e., nose-up pitch inputs) can exacerbate stall or prevent recovery.

How does pilot know condition is resolved/recovered?

- Cessation of stall warning alerts.

Issues with regard to multiple concurrent non-normal conditions

- Condition may devolve to engine surge and/or wing-walking (roll reversals from stall exacerbated by pilot rudder/wheel inputs).
- Possible passenger injuries and aircraft damage.

B737NG Alerting Issues – Stall

2. Initiating Condition: Increasing load factor in nose-low, high bank upset, autopilot disengaged

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	Flashing box on digital airspeed display	AOA-compensated airspeed, not g-compensated				Increased airspeed
	PLI on PFD/EADI nears/touches airplane symbol	AOA				Reduction of AOA
	Red/black band on airspeed indicator rising towards airspeed pointer	Bottom of amber band=top of red/black band is stick shaker onset and is g (AOA) compensated			Airspeed cues depend on proper AOA compensation	Reduction of AOA
Aural Alerts	Airspeed Low (if installed based on EGPWS model)	AOA-compensated airspeed, not g-compensated				Increased airspeed
	Stick shaker (sound of)	AOA				Reduction of AOA
	GPWS "Bank angle"	Bank angle >35 degrees		This is not an alert to the stall, but rather to the excessive bank angle from the roll upset		Reduction of bank angle
Tactile Alerts	Stick shaker	AOA				Reduction of AOA
Visual Cues	Airspeed indication in amber or red/black band	Top of amber band is minimum maneuvering speed (not g-compensated). Bottom of amber=top of red/black band is stick shaker onset and is g (AOA) compensated	Indicated airspeed at stall will be greater than usual due to load factor		Airspeed cues depend on proper AOA compensation	Reduction of AOA

B737NG Alerting Issues – Stall

2. Initiating Condition: Increasing load factor in nose-low, high bank upset, autopilot disengaged – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Cues	PFD/ADI indications of uncommanded pitch		Uncommanded pitch/roll and sink rate cues from stall are extremely difficult to isolate and identify during a dynamic roll upset, so pilots may be very unlikely to interpret them as signifying a stall (especially in the absence of stick shaker cues).	Pilots do not usually receive simulator training for stall at increased load factor/during roll upset so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		
	Roll rate of PFD/EADI		Uncommanded pitch/roll and sink rate cues from stall are extremely difficult to isolate and identify during a dynamic roll upset, so pilots may be very unlikely to interpret them as signifying a stall (especially in the absence of stick shaker cues).	Pilots do not usually receive simulator training for stall at increased load factor/during roll upset so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		
	Sink rate on vertical speed display		Uncommanded pitch/roll and sink rate cues from stall are extremely difficult to isolate and identify during a dynamic roll upset, so pilots may be very unlikely to interpret them as signifying a stall (especially in the absence of stick shaker cues).	Pilots do not usually receive simulator training for stall at increased load factor/during roll upset so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		
Aural Cues	Wind noise		Wind noise is not a reliable cue to angle-of-attack, but loud wind noise may potentially mislead pilots into thinking they are not stalling during a high-speed stall			

B737NG Alerting Issues – Stall

2. Initiating Condition: Increasing load factor in nose-low, high bank upset, autopilot disengaged – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Tactile/ Somatic Cues	Unusual wheel/column forces		Changes in the required control forces from stall are extremely difficult to isolate and identify during a dynamic roll upset, so pilots may be very unlikely to interpret them as signifying a stall (especially in the absence of stick shaker cues).	Pilots do not usually receive simulator training for stall at increased load factor/during roll upset so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		
	Aerodynamic buffet	AOA (natural)	Buffet cues from stall are extremely difficult to isolate and identify during a dynamic roll upset, so pilots may be very unlikely to interpret them as signifying a stall (especially in the absence of stick shaker cues). Also may be confused with high speed buffet.	Pilots do not usually receive simulator training for stall at increased load factor/during roll upset so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		

Expected Pilot Response(s)

- Disconnect autopilot and autothrottle
- Apply nose down pitch control until stall warning is eliminated
- Apply nose-down trim as needed
- Roll wings level
- Adjust thrust as needed
- Check speedbrakes retracted
- Return to the desired flightpath

Possible sources of confusion with regard to pilot response(s)

- Stall in nose-low condition (or devolving to nose-low condition) can require counter-intuitive pitch-down control inputs.
- If terrain proximity, the pilot may have to pitch down while being presented with a "Pull Up" GPWS warning.
- Erroneous pilot inputs (i.e., nose-up pitch inputs) can exacerbate stall or prevent recovery.

B737NG Alerting Issues – Stall

2. Initiating Condition: Increasing load factor in nose-low, high bank upset, autopilot disengaged – Cont.

How does pilot know condition is resolved/recovered?

- Termination of stall warning alerts.

Issues with regard to multiple concurrent non-normal conditions

- Recovery from stall condition must be followed immediately by recovery from nose-low, high bank upset condition.
- Possible passenger injuries and aircraft damage.

B737NG Alerting Issues – Stall

3. Initiating: Wing ice accumulation

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	None: PLI is present but may not be touching the aircraft symbol when the stall occurs (suggesting to the pilot that the aircraft is not stalling)		The expected alerts and cues will be absent		Alerts and cues are masked by the icing condition which causes the aircraft to stall at lower-than-normal AOA	
Aural Alerts	None		The expected alerts and cues will be absent		Alerts and cues are masked by the icing condition which causes the aircraft to stall at lower-than-normal AOA	
Tactile Alerts	None		The expected alerts and cues will be absent	Pilots are trained extensively to associate stick shaker as trigger to stall recovery; in absence of stick shaker (warning system failure or stall at lower-than-nominal AOA) they may not interpret the secondary cues of buffet, roll, etc. as being related to stall.	Alerts and cues are masked by the icing condition which causes the aircraft to stall at lower-than-normal AOA	
Visual Cues	None: airspeed appears to be adequate but is not; airplane may stall while indicated airspeed is in the amber band but not in or touching the red/black band		The expected alerts and cues will be absent	Pilots do not usually receive simulator training for stall at increased load factor/during roll upset so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.	Alerts and cues are masked by the icing condition which causes the aircraft to stall at lower-than-normal AOA	

B737NG Alerting Issues – Stall

3. Initiating: Wing ice accumulation – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Cues	PFD/ADI indications of uncommanded pitch		In the absence of the expected, salient alerts, these cues may not be interpreted as being related to stall	Pilots do not usually receive simulator training for stall at reduced AOA so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		
	Roll rate of PFD/EADI		In the absence of the expected, salient alerts, these cues may not be interpreted as being related to stall	Pilots do not usually receive simulator training for stall at reduced AOA so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		
	Sink rate on vertical speed display		In the absence of the expected, salient alerts, these cues may not be interpreted as being related to stall	Pilots do not usually receive simulator training for stall at reduced AOA so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.		
Aural Cues	None		The expected alerts and cues will be absent	Pilots do not usually receive simulator training for stall at reduced AOA so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.	Alerts and cues are masked by the icing condition which causes the aircraft to stall at lower-than-normal AOA	

B737NG Alerting Issues – Stall

3. Initiating: Wing ice accumulation – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
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Tactile/ Somatic Cues	Buffet; unusual wheel/column forces (autopilot off) or displacements (autopilot on)	AOA (natural)	In the absence of the expected, salient alerts, these cues may not be interpreted as being related to stall	Pilots do not usually receive simulator training for stall at reduced AOA so they are not accustomed to recognizing/reacting to these cues in the stress, novelty, and workload of a roll upset.	Alerts and cues are masked by the icing condition which causes the aircraft to stall at lower-than-normal AOA	Reduction of AOA
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Expected Pilot Response(s)

- Disconnect autopilot and autothrottle
- Apply nose down pitch control until stall warning is eliminated
- Apply nose-down trim as needed
- Roll wings level
- Adjust thrust as needed
- Check speedbrakes retracted
- Return to the desired flightpath

Possible sources of confusion with regard to pilot response(s)

- In the absence of the usual salient alerts, the pilots may not realize that the aircraft is stalled.
- Erroneous pilot inputs (i.e., nose-up pitch inputs) can exacerbate stall or prevent recovery.

How does pilot know condition is resolved/recovered?

- Difficult to know, related to cessation of uncommanded pitch/roll/sink.

Issues with regard to multiple concurrent non-normal conditions

- Condition may devolve to engine surge and/or wing-walking (roll reversals from stall exacerbated by pilot rudder/wheel inputs).
- Possible passenger injuries and aircraft damage.

B737NG Alerting Issues – Stall

4. Initiating: False stall warning during takeoff rotation

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
Visual Alerts	PLI touches airplane symbol on PFD/EADI (false indication)	AOA	Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored.		Inhibition/suppression not relevant because the alert is false	Alert or cue is not terminated as it is invalid
Aural Alerts	Stick shaker, sound of (false indication)	AOA	Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored.		Inhibition/suppression not relevant because the alert is false	Alert or cue is not terminated as it is invalid
Tactile Alerts	Stick shaker (false indication)	AOA	Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored.		Inhibition/suppression not relevant because the alert is false	Alert or cue is not terminated as it is invalid
Visual Cues	Normal vertical speed, altimeter, and airspeed indications on PFD, as well as view through the windshield of the aircraft climbing (if VMC) are subtle cues that the aircraft is not stalling		Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored.			
Aural Cues	None					

B737NG Alerting Issues – Stall

4. Initiating: False stall warning during takeoff rotation – Cont.

Type	Alert or cue	Threshold for alert or cue to be presented	Confusion regarding alert or cue	Other issues with regard to alert or cue	When alert is inhibited/suppressed or when cue is masked	How alert or cue is terminated
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Tactile/ Somatic Cues	Normal vertical acceleration from rotation into climb is a subtle cue that the aircraft is not stalling		Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored.			
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Expected Pilot Response(s)

- Ignore false alerts and cues.
- Do not reject takeoff.

Possible sources of confusion with regard to pilot response(s)

- Conflict between highly salient, but false alerts and subtle, valid cues: Salient alerts that the airplane is stalled must be compared with normal rotation/climb performance under extreme time pressure, and ignored.
- Pilots are trained to respond to stall warnings/alerts immediately and without deliberation, decreasing the likelihood of identifying the false warning through effortful analysis and suppressing the reaction to the false warning.
- Split-second decision to perform a late rejection or continue.

How does pilot know condition is resolved/recovered?

- Observe normal takeoff and climb performance.

Issues with regard to multiple concurrent non-normal conditions

- None unless pilot takes unneeded actions, such as high speed RTO.